Getting the Incentives Right: Learning Science and Team-Based Learning in Economics[1]

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A. INTRODUCTION

Over the past two decades, learning sciences research has illustrated the importance of understanding how students learn as a foundation for effective teaching. Yet, most economics instructors do not explicitly incorporate research findings on how students learn in their course design or teaching practices. The purpose of this paper is to illustrate how a particular teaching practice, Team-Based Learning (TBL), provides a systematic framework for incorporating evidence-based teaching practices into college economics instruction.

TBL, as both a conceptual course structure and practical pedagogical practice, directly addresses common challenges faced by economics instructors attempting to incorporate active-learning teaching strategies into their courses, including how to motivate students to put in the requisite effort *out of class* to learn basic concepts, so that class time can focus on higher-order applications, and promoting the engagement of all students *in the classroom* in the learning process. Our hope is that understanding the structure of TBL, its application to economics courses, and its connection to learning sciences principles will motivate more instructors to adopt TBL-based teaching practices in their own courses.

B. THE ROLE OF LEARNING SCIENCES RESEARCH IN TEACHING AND LEARNING

The seminal *How People Learn* (National Research Council, 2000) laid the groundwork for today's increased interest in the "science of learning" and its focus on the importance of "learning with understanding." A key feature of *How People Learn* was its intentional linkage between learning sciences research and effective teaching practices grounded in that research.

Learning sciences research also undergirds the movement in STEM disciplines to adopt a "scientific approach to teaching" (Handelsman, et al., 2004; Handelsman, 2006; Wieman, 2010; and Wieman, 2015a, 2015b), including the use of learning-sciences-informed teaching practices, to improve student learning. In the last decade, discipline-based education research, primarily in STEM disciplines, has led to national calls for increased use of evidence-based

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instruction (National Academies of Science; 2012, 2015) grounded in learning sciences research, including disciplinary initiatives such as *Vision and Change* (AAAS, 2011) in biology and the *AAU STEM Education Initiative*, focused on changing teaching practices in large U.S. research universities.[2]

Interest in evidence-based teaching practices grounded in the "science of learning" has unleashed a plethora of books and resources focused on intentionally and systematically using learning sciences research to inform college teaching practices (Brown, Roediger, and McDaniel, 2014; Weinsten, Sumeracki, and Caviglioli, 2019; Schwartz, Tsang, and Blair, 2016; Ambrose, Bridges, DiPietro, Lovett, and Norman, 2010; Eyler, 2018; Agarwal and Bain, 2019; Carey, 2015, to name just a few). A common feature in this work is the need for students to be actively engaged in the learning process. Learning sciences research provides evidence-based suggestions for intentionally structuring students' active engagement to increase the potential for learning.

However, despite nearly twenty years of attention on learning sciences research and its support for evidence-based teaching practices, only limited progress has been made in STEM disciplines (see, e.g., AAAS, 2015; Singer, Nielsen, & Schweingruber, 2012; Kober, 2015; Deslauriers, et al., 2019). As noted by Deslauriers, et al. (2019, p. 19251; see also the twelve references included in this paragraph in the original article):

> Students learn more when they are actively engaged in the classroom than they do in a passive lecture environment. Extensive research supports this observation, especially in college level science courses. Research also shows that active teaching strategies increase lecture attendance, engagement, and students' acquisition of expert attitudes toward the discipline. Despite this overwhelming evidence, most instructors still use traditional methods, at least in large-enrollment college courses.

As Dancy, Henderson and Turpen (2016) point out, even in disciplines with significant evidence-based pedagogical research, such as physics, sustained instructional change has been difficult.

The same is true in economics, as recent surveys of teaching by Goffe and Kauper (2014), Watts and Schaur (2011), and Watts and Becker (2008) illustrate. This dominance of the lecture approach occurs despite the fact that in economics, as in other disciplines, substantial research indicates that students learn more in classes that employ student-centered, active-learning pedagogy (e.g., see Lage et al., 2000; Simkins and Maier, 2004; Emerson and Taylor, 2004; Yamarik, 2007; Balaban et al., 2016). Although signs of change are emerging, "[a]doption of an alternative teaching innovation [in college economics courses] is likely to be more of an exception or supplement to traditional instruction" (Allgood et al., 2015).

Simkins and Goffe (2015) promote the intentional integration of learning sciences principles in economics teaching to improve active learning outcomes, while Boyer and Goffe (2018) demonstrated the impact of employing a collection of evidence-based teaching practices in a large-enrollment principles course. Yet, despite the resources available (see, e.g., the online economics pedagogical portal, *Starting Point: Teaching and Learning in Economics*, https://serc.carleton.edu/econ) and the demonstrated effectiveness of evidence-based, active-

[2] See https://visionandchange.org/ and https://www.aau.edu/education-community-impact/undergraduate-education/undergraduate-stem-education-initiative-3, respectively.

learning teaching practices across disciplines, economics instructors often find it difficult to implement teaching practices grounded in learning sciences research in their courses, inhibiting their use. This paper is aimed at reducing the marginal cost of integrating one particular type of evidence-based teaching practice, TBL, in undergraduate economics courses. Our hope is that by helping to familiarize economists with the TBL framework and illustrating its use in economics (see the Appendix), more economists will consider adopting TBL-informed teaching practices in their courses.

In the remainder of the paper we describe TBL pedagogy and why it works, based on the learning sciences principles it supports. In the next section we provide a brief overview of TBL, followed by a section highlighting key learning sciences principles embedded in TBL pedagogy. Next, we discuss ways that specific elements of TBL can be applied in more traditional class settings to improve student learning and serve as a way to "try out" TBL without committing to a whole-course redesign. We end with a summary of the discussion and questions for future research. In the Appendix, we illustrate how TBL can be implemented in a typical principles-level microeconomics course.

C. A BRIEF OVERVIEW OF TEAM-BASED LEARNING

Team-based learning was first developed by Larry Michaelsen in 1979 as a way to actively engage large-enrollment classes in a business school setting (Sibley and Ostafichuk, 2014). Since then, TBL has been adopted in a wide variety of disciplines, including medical and health sciences, engineering, law, social sciences, and humanities (Michaelsen, Bauman Knight, and Fink, 2004; Michaelson and Sweet, 2008; Sweet and Michaelsen, 2012). Sibley and Ostafichuk's *Getting Started with Team-Based Learning* (2014) provides a comprehensive introduction to TBL pedagogy; a concise, free "TBL Primer" (Sibley and Roberson, 2018) is also available from Sibley's *LearntTBL* web site.[3] Here we provide only a brief overview of the key features of TBL.

TBL in Economics: The Appendix provides a step-by-step description of TBL implementation in a principles of microeconomics class, using examples from an externalities module of that course.

TBL is a whole-course pedagogical approach that holds students accountable for learning factual information and basic applications outside of class and engages students during class time through use of application exercises (AEs) designed to stimulate deep conceptual thinking and metacognition. Typically, TBL-based courses are divided into a series of modules lasting 2-3 weeks, each incorporating a Readiness Assurance Process (RAP) and multiple Application Activities/Exercises (AEs), as shown in Figure 1 on the following page.

Each module generally focuses on a key student content area or learning outcome in a course, often spanning multiple chapters in a traditional textbook. For example, in economics, a TBL module might be structured around imperfect competition and include both monopoly and oligopoly chapters. Additional information about the RAP and AE components of TBL is provided in the sub-sections that follow below.

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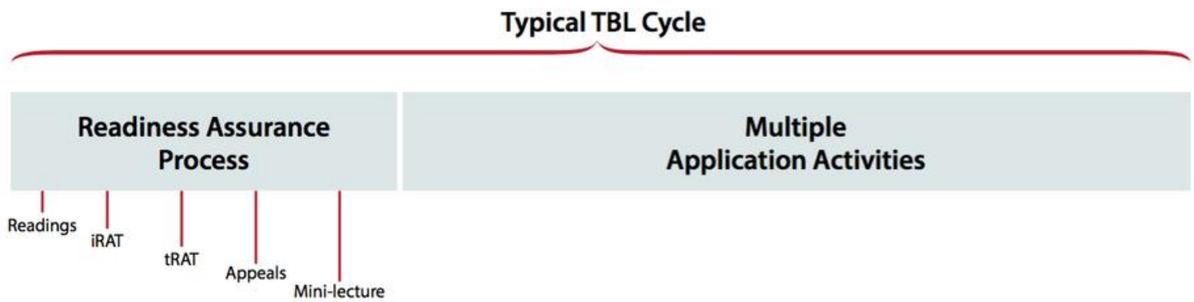
[3] Jim Sibley provides one of the best introductions to TBL at https://learntbl.ca/. See, in particular, the free workshop materials posted there (https://learntbl.ca/book/other-materials/). For an extensive overview of how to implement TBL pedagogy in economics courses, see *Starting Point: Teaching and Learning Economics* (2012) at https://serc.carleton.edu/econ/tbl-econ/index.html.

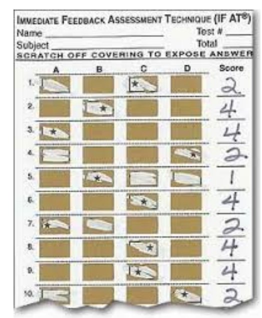
Figure 1. The TBL Module Framework



Source: Sibley and Spiridonoff (2014); used with permission.

Readiness Assurance Process. Each module begins with students *individually* completing a low-stakes multiple-choice quiz (an individual Readiness Assurance Test or iRAT) on module-focused readings or other materials. Individual team members are not given any indication whether their answers are correct or incorrect at the time they complete their iRATs. This individual test can be administered online before class or on paper in class.

Figure 2
IF-AT Form



Teams of students then take the same multiple-choice quiz (a team Readiness Assurance Test or tRAT) using an Immediate Feedback Assessment Technique (IF-AT) scratch-off form (see Figure 2) (http://www.epsteineducation.com/home/about/) that encourages entire-team participation in answering the questions. As students sequentially scratch off the boxes on the team's IF-AT form, the correct quiz question answer is ultimately revealed (with a star), providing immediate feedback on the team's choice. Points are typically awarded in a nonlinear 4-2-1 manner, based on whether teams select the correct answer on the first, second, or third scratch, further promoting focused team interaction prior to selecting a team answer. Overall RAT scores are generally calculated as the average of the individual (iRAT) and team (tRAT) quiz scores, providing yet another incentive for all team members to fully engage in the tRAT process – their score for the RAT assignment is dependent on the answer agreed upon by the team. Scores on tRATs generally far exceed the average of iRAT scores within the team, providing evidence of the efficacy of this approach.

RAT quiz questions are intended to promote learning of baseline conceptual knowledge needed for the higher-level application and evaluation exercises that make up the bulk of each TBL module. However, RAT questions themselves can reach into the application level of Bloom's cognitive taxonomy.

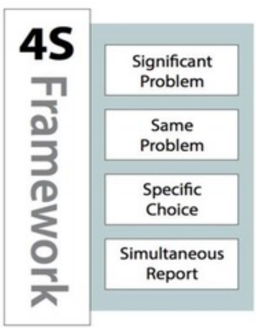
Following the tRAT, teams can consult the assigned material to challenge in writing any question that has multiple correct answers, has no correct answer, or draws on knowledge that students could not reasonably be expected to have. If accepted, the team is awarded double the points involved in the challenge. While challenges do increase the time requirements of the team quiz slightly, the challenge process provides additional opportunities to reinforce student learning and retention. In most cases, the professor follows up the appeal process (if needed) with an abbreviated mini-lecture on higher-level concepts and tools that will be used in the module.

Application Exercises. The remaining classes in a TBL module focus on team-based completion of Application Exercises (AEs) that are intrinsically interesting, contain multiple tradeoffs that must be considered from diverse perspectives, and require teams to make a specific choice from a list of alternatives (similar to a high-level multiple-choice question).

Economics AEs: *Starting Point: Teaching and Learning Economics* includes a library of more than 130 ready-to-use economics Application Exercises, including instructions for their use; see https://serc.carleton.edu/econ/tbl-econ/activities.html.

AEs generally are completed in a single class period, but depending on complexity, could span two or three classes. At the completion of each AE, student reporters from each team reveal their choices simultaneously and proceed to engage in a discussion of the information and methodology that informed their choice. This process, described as the "4S Framework" in TBL, is summarized in Figure 3 below.

Figure 3
The TBL 4S Framework



Source: Sibley and Spiridonoff (2014); used with permission.

Note that, according to the 4S Framework: (1) Each AE is developed around a "significant problem" related to the module's learning outcome; AEs are aimed at engaging students in high-level conceptual problems that go beyond traditional "problem-solving" that typically focuses on numerical calculations or graph-drawing. The AE may not have a single "correct" answer; instead the focus is on developing understanding of the underlying concepts embedded in the AE. In the best case, AEs are developed so that the knowledge of *all* students on the team is required to provide a nuanced justification of the team's decision in the AE. (2) All teams work on the same problem. This promotes cross-team discussion and debate at the conclusion of the AE, after the teams have reported their choices (see 4 below). (3) Teams are required to make a specific choice from a limited number of options (typically four or five) related to the problem; these could be policy choices, position statements, or other choices that require students to carry out a conceptual analysis related to the AE. Team members must agree on one answer, which will ultimately be shared with the class. (4) Once each team has made its response choice, all teams simultaneously reveal their choices to the class, often using colored cards with letters of the option choices – A, B, C, D, for example. The instructor then looks for differences in answers among the teams and randomly selects members from the teams to defend their choices using the concepts and tools relevant for the AE. This "student debriefing" is often a rich interchange of ideas that helps students solidify their understanding of the underlying concepts. Professors provide feedback and additional "mini-lectures" as necessary after the student debriefing and before the next AE. This AE team exercise – report-out – feedback/debrief cycle is repeated throughout the module and across modules in the course.

Formal Peer Evaluation. Though not illustrated in Figure 1, formal peer evaluation is an important component of TBL. During the semester, students provide their teammates with formative feedback on their performance in the team in areas such as active listening skills, level of preparation, ability to provide and accept constructive feedback, and openness to alternative ideas. At the end of the term, a similar evaluation counts toward the course grade. While there are numerous ways to incorporate teammate feedback into a TBL course (see Michaelsen, Bauman Knight, & Fink, 2002, or Sibley & Ostafichuk, 2014, for examples) holding students accountable to peers for their work outside of class and their performance as team members helps ensure earnest student effort on team tasks.

D. LEARNING SCIENCES RESEARCH AND TEAM-BASED LEARNING

Buskist and Groccia (2011) highlight TBL as an evidence-based teaching method, consistent with research on effective teaching practices and student learning from a variety of sources. While not originally developed from a learning sciences framework, TBL pedagogy aligns closely with research findings from the learning sciences that illustrate the benefits of actively engaging students in the learning process in systematic and intentional ways (see, for example, National Research Council, 2000; Dweck, 2006; Ambrose et al., 2010; & Brown et al., 2014).

TBL is consistent with specific “key learning strategies from cognitive research (that) have been consistently found to be effective, and can be broadly applied to education” (Weinstein, Sumeracki, & Caviglioli, 2019, pp. 83-85), including (1) retrieval practice, (2) spaced/distributed practice, (3) elaboration, and (4) use of concrete examples.[4] In addition, TBL supports another evidence-based learning sciences strategy, a “time for telling” (Schwartz and Bransford, 1998) and research-based strategies for effective group work.

Classroom-based research also provides direct evidence of TBL’s impact on student learning outcomes. Sisk (2011), Haidet, et al. (2014), Burgess et al. (2014) and Reimschisel, et al. (2017) summarize the results of numerous published studies of TBL effectiveness, much of it in health sciences-related courses. The results generally indicate that TBL improves both student engagement and learning, although definitive studies are lacking.

Research on TBL in Economics: Research on TBL’s impact on student learning in economics is limited, but findings by Espey (2012), Imazeki (2015), and Hettler (2015) indicate similar results as those found in other disciplines. The results from Espey are particularly encouraging, as they suggest that TBL has a marginally positive impact on exam scores (although not course grades) for minority and first-generation college students.

The classroom-based assessment results for TBL summarized above provide evidence that TBL improves learning outcomes for students relative to traditional lecture-based teaching practices, but do not explain *why* the pedagogy works. In the rest of this section, we highlight how the structure and specific characteristics of TBL align with the key learning sciences strategies/principles listed above and systematically promote their use.

THE TBL COURSE STRUCTURE PROMOTES EVIDENCE-BASED TEACHING PRACTICES

Central to the success of TBL is its “whole course” intentional design that promotes student learning through practices that align well with learning sciences principles. TBL courses begin with student learning outcomes in mind; the module-based approach encourages instructors to first think carefully about which disciplinary conceptual ideas will be included in the course

[4] These four learning science-supported “strategies for effective learning” are among six listed by Weinstein, Sumeracki, & Caviglioli (2019) as being consistently noted in literature reviews (see Dunlosky, Rawson, Marsh, Nathan, & Willingham (2013), Weinstein, Madan, & Sumeracki (2018), and Pashler, et al. (2007)). The other two are dual coding and interleaving. See also the *Learning Scientists* web site: https://www.learningscientists.org/; this site provides a wealth of resources for students and instructors, including downloadable posters and videos explaining the benefits of these strategies and how to use them.

and then focus on how those conceptual ideas will be learned, applied, and assessed within each module. This is an example of the "backward design" principles promoted by Fink (2003) and Wiggins and McTighe (2008) that create "significant learning experiences" (Fink, 2003). Well-designed TBL courses systematically move students from lower levels of Bloom's cognitive taxonomy (knowledge and comprehension) to higher levels (application, analysis, and evaluation) by continually scaffolding the learning process within each module – starting with individual preparation and the Readiness Assurance Process (RAP) before moving to higher-level Application Exercises that focus on application of concepts. The process is repeated in modules throughout the semester, repeatedly reinforcing this learning cycle with students.

STRATEGY 1: RETRIEVAL PRACTICE

Weinstein, Sumeracki, and Caviglioli (2019, pp. 83-85), note that among the six research-based learning strategies on their list, retrieval practice and spacing/distributed practice have received the most support from cognitive science research. In this section we focus on the role of retrieval practice in TBL, followed by spacing/distributed practice.

At its core, all evidence-based teaching advice stems from the fundamental process of learning: learning begins with perception and encoding, and its long-term efficacy is dependent on consolidation, retrieval and use (Brown, Roediger, and McDaniel, 2014). Teaching practices that promote these processes will improve student learning. Retrieval practice helps to create and solidify long-term memory and improves the ability of students to apply learning in new situations.

As Brown, Roediger, and McDaniel (2014, p. 28) explain, "To be effective, retrieval must be repeated again and again, in spaced out sessions so the recall, rather than becoming a mindless recitation, requires some cognitive effort."[5] Research on the need to reinforce brain pathways through retrieval is well established in cognitive science; much of the research is focused on the benefits of testing memory. Dunlosky et al. (2013) rate "practice testing," a type of retrieval practice, as a high impact, research-supported activity. For reviews of the impact of retrieval practice on student learning, see Roediger & Karpicke (2006); Roediger, Putnam, and Smith (2011); and Roediger and Karpicke (2018). Agarwal, Roediger, McDaniel, & McDermott, K.B. (2013) provide a useful "how to" guide on incorporating retrieval practice in the classroom or online. Strategies include clicker questions, Peer Instruction, "exit tickets," multiple-choice quizzes, writing prompts, and Just-in-Time Teaching assignments.

The TBL class structure requires constant retrieval practice of students throughout every class. Students prepare much of the material on their own before the first class period of each module. Subsequently, students must make an effort to recall material to perform the iRAT; they must then express their own understanding, hear that of others, provide and receive feedback, and modify their own comprehension as each quiz question is discussed in advance of team "scratch-off" choice(s) on the IF-AT form. In addition, each of the multiple AEs requires students to retrieve information from the preparatory material, combine it with pre-existing knowledge, express their support for one possible decision, interact with teammates to make a team choice, modify their own understanding, prepare to present the team's reasoning in the

[5] This is also related to the importance of incorporating "desirable difficulties" into the learning process to promote learning, as discussed in Bjork (1994).

discussion among team reporters, and then hear from the instructor about work on the issue at hand by experts in the field. Each step provides additional retrieval practice.

A key element in improving learning through retrieval practice is immediate feedback, which should be always be provided after retrieval practice. Schwartz, et al. (2016, pp. 64-77) notes that effective feedback needs to be timely, specific, understandable, and nonthreatening. For example, ""When students take a test, it is useful to deliver feedback while they can still remember how they solved the problem. Otherwise, they will not be able to remember which of their thoughts was responsible for the error." (p. 68)

Based on the discussion in the previous section, it is easy to see that TBL systematically and intentionally supports retrieval practice. Retrieval is reinforced multiple times throughout each module and then repeated across modules throughout the semester. The Readiness Assurance Process, with both individual and team-based quizzing, promotes effortful retrieval of module content after pre-module reading is completed. Moreover, the team-based tRAT process using the IF-AT form provides immediate feedback on whether the team is correctly understanding the concepts covered by the questions. The feedback (Was the selected answer correct? What is the correct answer?) targets a specific concept, idea, or skill (e.g. understanding graphs) that students previously prepared for (via the pre-RAT reading and iRAT) and is either affirmed (a correct answer) or is the basis for further discussion and feedback.

Application Exercises provide repeated practice with higher-level application of concepts, promoting effortful recall with "desirable difficulties" (Bjork, 1994), a key component of effective retrieval practice. The 4S process requires TBL teams to consult with each other before making a specific choice, providing feedback to all students regarding their thinking processes, while the simultaneous reporting and debriefing provide additional immediate feedback to everyone in the class on the analytical thinking processes and concepts driving the application exercise. As in the RAT process, the feedback is specific, focused on the application at hand, and made understandable through the team discussion and whole-class debriefing.

STRATEGY 2: SPACED/DISTRIBUTED PRACTICE

Spaced or distributed practice is closely related to retrieval practice and focuses on *when* studying, or retrieval practice is done. Spacing/distributing studying and practice in smaller increments over time, rather than in fewer, longer, "massed practice" sessions (often referred to as "cramming") has been shown to improve long-term learning of students in a wide variety of tasks (although massed practice can lead to higher short-term learning outcomes when testing is done soon after massed learning sessions). Like retrieval practice, Dunlosky et al. (2013) rate spaced/distributed practice as a high impact, research-supported activity. For reviews of the student learning impact of spaced practice, see Carpenter, Cepeda, Rohrer, Kang, & Pashler (2012) and Fiske & Kang (2016). As noted by Weinstein, Sumeracki, and Caviglioli (2019), "Spacing may be effective in part because it increases what some researchers call 'storage strength – a measure of deep learning… If we forget a little before we restudy information, this allows us to boost that storage strength when we re-encounter the information." (pp. 92-93)

TBL inherently promotes spaced retrieval practice by motivating student engagement with the material early on and then spreading out the need to retrieve key course concepts and apply them repeatedly within a module, not just for a single exam. While mini-lectures occur within the TBL course design, they form a relatively small part of class time. Much more time is spent actively practicing course concepts via AEs, which require students to retrieve ideas and concepts first introduced in the Readiness Assurance Process and then apply them in new and novel ways multiple times over, say, a two-week period. As a result, retrieval practice is naturally distributed across each module, and across modules throughout the course. TBL provides a model for their own study practices by design.

STRATEGIES 3 AND 4: USE OF ELABORATION AND CONCRETE EXAMPLES

In Chapter 9 of *Understanding How We Learn: A Visual Guide*, Weinstein, Sumeracki, and Caviglioli (2019) summarize the roles that elaboration and concrete examples play in developing *understanding*, a deep (rather than surface) level of learning. They note (p. 101) that for understanding to occur, connecting new information to pre-existing knowledge is necessary, a process that can be increased through elaboration. Learning for understanding is enhanced through "elaborative interrogation," a type of questioning that involves asking and answering "how" and "why" questions. Concrete examples also promote understanding by illustrating abstract ideas and making them easier to understand, especially when multiple examples with different (surface) features are used to illustrate the same concept or idea.

Elaboration. Anderson (1983, p. 285) states that "one of the most potent manipulations that can be performed in terms of increasing a subject's memory for materials is to have the subject elaborate on the to-be-remembered material." The structure of TBL classes requires students to elaborate on to-be-learned material throughout class time. During the tRAT, for example, students consider each question together, explaining to each other why one answer is correct and another incorrect, coming to consensus on a choice, then continuing the process if the earlier choice is incorrect. The challenge to a question, when made, requires further elaboration on course concepts as students compose a written argument that a quiz question is flawed.

TBL AEs require students to elaborate on "how" and "why" their team chose a specific answer for the AE, which typically focuses on a concrete, real-world example of economic concepts, data, or policy actions. Each team member needs to be ready to provide this "elaboration" to the rest of the class during the debriefing session following the AE or risk losing points for the entire team (if they are not prepared). The AE process is a structured form of "elaborative interrogation" – both within the team discussions and during the debriefing session. As Weinstein, Sumeracki, and Caviglioli (p. 105) note, "as you are elaborating, you are making connections between old and new knowledge, making the memories easier to retrieve later."

Concrete Examples. Using concrete examples can be helpful for learning abstract ideas, as long as students remember the underlying abstract idea and not simply the surface details of the example – a big issue for novice learners. Weinstein, Sumeracki, and Caviglioli (p. 111) recommend providing students with multiple examples with differing surface details for a specific idea, advice based on seminal research on this topic by Gick & Holyoak (1983). The National Research Council (2000, p. 74) reaches a similar conclusion: "Reasoning can be improved when abstract logical arguments are embodied in concrete contexts." *How Students Learn* (National Research Council, 2005, p. 6) goes further, noting that "… concepts are given meaning by multiple representations that are rich in factual detail. Competent performance is built on neither factual nor conceptual understanding alone; the concepts take on meaning in the knowledge-rich contexts in which they are applied." Teaching in this way, provided instructors make explicit the connections between the concrete example and abstract concept, increases students' ability to effectively transfer concepts to new situations.

TBL AEs require repeated elaboration of course concepts in the context of numerous concrete examples. According to Weinstein, Madan, and Sumeracki (2018) concrete examples improve learning by concisely conveying information and making that information easier to remember. Lab research indicates that concrete examples provided along with abstract concepts improve student retention of the latter (Caplan and Madan, 2016; Madan, Glaholt, and Caplan, 2010; Paivio, 1971), while Gick and Holyoak (1983) show that using multiple examples improves students' ability to transfer learning to new contexts.

While use of concrete examples is not exclusive to TBL, AEs in economics courses typically involve real-world concrete examples that require students to make connections between real-world phenomena and abstract economic concepts and models. A sequence of increasingly complex AEs is used throughout a module, providing students with numerous opportunities to apply abstract concepts to real-world examples, increasing the likelihood of being able to transfer the economic concepts and models to new and unfamiliar situations.

TBL Application Exercises – Concrete Examples and Elaborative Interrogation: The example in the Appendix (Table A.3) illustrates how well-constructed economic AEs promote students' application of economic concepts and evaluation of real-world policy decisions in a way that is different from typical "problems" used in textbooks, classroom activities, or homework assignments.

STRATEGY 5: A TIME FOR TELLING

How can direct instruction, i.e. lectures, best support student learning? In the learning sciences literature there is strong evidence for direct instruction if it follows student engagement (Schwartz 1990, 2011). In other words, the usual practice should be reversed. Instead of first lecturing about a concept and then demonstrating its validity through an active learning exercise such as a classroom experiment, it is better for students to explore the topic before direct instruction. In this way students understand the problem to be addressed: why there is a need to investigate the concept and why might the student's initial conceptions be incorrect or insufficient. Psychologist Daniel Schwartz calls this approach a "time for telling" (Schwartz and Bransford, 1998; Schwartz, et al., 2011) or "Just in time telling" (Schwartz, et al., 2016) based on laboratory research in which students learned new concepts under varying order of activities and lecture. Similarly, Brown, Roediger and McDaniel (2014, p. 101) conclude in *Make it Stick: The Science of Successful Learning,* "Trying to come up with an answer rather than having it presented to you, or trying to solve a problem before being shown the solution, leads to better learning and longer retention."

Team Based Learning creates two places in which a "time for telling" can occur. The first is straightforward: if the team Readiness Assurance Process reveals consistent errors on a question, there is a propitious moment to for the instructor to address the issue in a short mini-lecture. The second type of "time for telling" follows each Application Exercise. The best AEs invite student discussion about the pros and cons of several answers. In this way students apply newly-learned concepts in new contexts, revealing the relevance of those concepts and the student thinking processes they uncover. The instructor can use the student interaction in the inter-team discussion to identify key points that need further explication in a mini-lecture and to reveal to students related work on the issue by experts in the discipline. Again, it is this appropriate 'time for telling' that has been shown to increase student learning more than direct instruction that precedes the activity.

STRATEGY 6: PROMOTING EFFECTIVE GROUP WORK

The learning sciences have a long tradition of emphasizing the importance of social interaction for successful mastery of new concepts. Social interaction forms the basis of relatively well-established pedagogies such as peer instruction (Schell and Butler, 2018) and other techniques that require students to interact. At the same time, learning sciences research also points to the need for careful attention to structuring these interactions. Simply putting students in groups and expecting learning to take place can in fact be counterproductive (Cooper, 2009, pp. 207-210).

Team-Based Learning puts into place many of the research-based recommendations for effective group work. The structure of TBL motivates student effort by having points on the line during team quizzes, posing significant AEs that require each student to weigh in with their perspective, and including formal teammate evaluation as part of the course grade.

Team formation and collaborative skills. Following recommendations from the cooperative learning literature (Cooper, 2009, pp. 207-210; Millis & Cottell, 1998, pp. 50-53), TBL requires teams formed by the instructor and lasting the entire course term. When students choose their own teams, the result is inevitably that friends group together, which limits team function by bringing issues from outside the class into play and by creating blocs of students inclined to vote together regardless of the logic and evidence presented in team discussion. Moreover, clusters of friends often lack the diversity of experience that is necessary to make the complex decision required by a good AE. Over the term, the instructor may provide supportive lectures or activities on collaborative skills, but the repeated practice of team RAPs and AEs offers hands-on practice in working together. In particular, these activities, along with peer evaluation, promote equal participation by all team members, counter-acting dominance by one student and free-riding by the others (Kagan 2014). In addition, learning sciences research has shown the importance of being accepted, valued, and included for increasing student motivation, engagement and persistence (Schwartz, Tsang, & Blair, 2016, p. 13).

Group-worthy tasks. Evidence from the learning sciences supports the use of "group-worthy tasks" (Schwartz, et al., 2016, p. 144) in which the team accomplishes more than any individual could do alone. The team RAP almost always results in higher scores that any individual (Michaelsen, Watson, & Black 1989). TBL Application Exercises engage students with a "significant problem" that has "specific choices." In this way, not only is the problem interesting, but it also focusses the team on concepts that the instructor has chosen as most important. After team discussion, the simultaneous reporting of each team's answer prompts talk between teams, not mediated by the instructor. Once again, TBL sets a structure in which students inherently are engaged with one another.

Explanation to peers. As noted above, learning sciences research emphasizes the importance of self-explanation (see Schwartz, et al., 2016, pp. 234-246) by students. Specifically, self-explanation is generative so that students "go beyond the information given," making "connections to their own knowledge," and monitoring their comprehension (p. 235). In TBL, most class time is spent on such self-explanatory talk. And, in contrast to full class discussion in which one student speaks at a time, team-based work has simultaneous student talk, greatly magnifying the time in which each student can express a viewpoint. The team RAPs encourage all students to agree on the answer before proceeding to scratch off their choice on the IF-AT form. AEs require that each student will be ready to stand and present the team's rationale for the specific choice. As a result, AE discussion prior to the simultaneous revealing of the specific choice is likely to be focused and detailed so that the team's answer will be well justified. Talk among teams following the answer reveal also will involve self-explanation as the spokesperson is talking to peers rather than the instructor.

E. IS WHOLE COURSE ADOPTION OF TBL NECESSARY TO IMPROVE LEARNING?

As noted here, TBL was developed as a whole-course pedagogy, and the resulting structure puts into practice a number of learning sciences principles to increase student learning. However, switching one's whole course to TBL poses a challenge for many instructors. While formal TBL advocates emphasize the positive impact of the systematic and coordinated structure of whole-course TBL pedagogy, and therefore discourage a piecemeal approach to TBL, we take a more pragmatic approach, encouraging instructors to begin incorporating TBL-inspired practices into their own teaching. We recognize the potential pitfalls of such an approach (Michaelson, Knight, & Fink, 2004, pp. 25 and 47-48), but believe that many of the elements of TBL can be added to a wide variety of economics courses to improve student learning immediately and, perhaps, to make possible a gradual shift to TBL over time. In short, we believe that the marginal benefits of TBL-informed teaching in economics, even if not integrated as a formal whole-course design, outweigh the potential marginal cost.[6]

GROUP QUIZZES AND USE OF IF-AT FORMS

Instructors find the use of IF-AT forms for in-class group quizzing to be easy and engaging to students, whether the quiz is a follow-up to the same multiple-choice quiz that students have taken individually or whether it is used without the prior individual quiz. Incorporating group quizzes with IF-AT forms offers students the opportunity to learn from other group members and engages all students in retrieval and elaboration activities as they jointly decide on quiz answers. If student groups are working effectively, every student can receive immediate feedback from group members on their understanding, as well as the opportunity to revise and restate their grasp of key concepts. In addition, students' disagreements in team discussions about challenging quiz questions builds a curiosity that will be satisfied by ensuing instruction.

Using IF-AT forms for group quizzes makes the endeavor more fun than traditional individual quizzes and also provides students with immediate feedback on the correct answer. This element of the TBL Readiness Assurance Process can be added to any economics course and requires neither a complete course overhaul nor acquisition of the class management skills necessary for the adoption of the whole-course TBL pedagogy.

USE OF APPLICATION EXERCISES

Like group quizzes using IF-AT forms, TBL Application Exercises can easily be incorporated into traditional economics courses as a form of group learning. Larry Michaelsen observes that "good application-focused group assignments foster give-and-take discussions because they focus on decision making (not writing) and enable students to share their conclusions in a form that enables prompt cross-class comparisons and feedback" (Michaelsen, Knight, and Fink, 2002, p. 44).

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[6] We are currently conducting an empirical study of the benefit of AEs as a learning tool, vis-à-vis traditional "textbook problems" in principles-level courses, whether designed as TBL or "traditional" courses.

Each application exercise (AE) is typically considerably longer than typical short-answer or calculation-based "problems" used in traditional economics courses, taking up as much as one or several class periods. Well-designed AEs (such as those in the TBL AE library at the *Starting Point* (2004) pedagogic portal, https://serc.carleton.edu/econ/tbl-econ/activities.html) promote effective retrieval practice and elaboration that is spaced out over time. The TBL AEs might draw on material from throughout the course, not just in the unit under study, interleaving students' review of course concepts in a way that increases learning and retention. Effective AEs are designed around concrete examples of course concepts and require the input of each member of the group to make a specific decision, providing opportunities for group members to elaborate on course concepts and to receive immediate feedback from peers. Economics, with its close connections to real-world events and policy decisions, is particularly well-suited to the use of AEs.

When using AEs in a course, the instructor's role becomes one of facilitating each group's engagement with the AE, perhaps by initially presenting an important framework of analysis, assisting teams with technical elements as they build consensus on a group-based answer, facilitating a vigorous argument among team reporters, and closing each activity by summarizing key points and providing information about the work of experts in the field on the matter at hand. Instructors using AEs in a traditional course might find it useful to move some or all of the AE set-up and debriefing outside of class by means of online screencasts posted to the course management system. Instructors interested in adding more active-learning in their classes can employ an occasional AE to increase students' practice with retrieval and elaboration of economic concepts based on concrete examples, while also providing immediate feedback from peers and instructor.

USING FIXED, INSTRUCTOR-SELECTED TEAMS

Student groups in TBL classes differ from those in many classrooms in the fact that TBL teams are selected by the instructor and remain fixed through the entire semester. Instructor selection is intended to increase the diversity within each team with the intent of enriching elaboration opportunities. Instructor-selected teams also are less likely to feature the voting blocs that sometimes emerge within teams and that stifle team discussions. The fixed nature of teams enables students to gain the trust level with each other that is necessary to foster open, wide-ranging explorations of course material and each student's free expression of their understanding of course material, their opinions on best approaches to each AE, and the values that inform their judgments on the choices offered in each AE. Instructors who regularly have students work in variable, self-selected groups can experiment with fixed, instructor-selected teams without having to adopt the full TBL pedagogy. Useful strategies for forming permanent, instructor-selected teams are available at https://learntbl.ca/team/.

F. SUMMARY/CONCLUSION

TBL has tremendous potential for adoption in economics education. As we demonstrate in this paper, TBL puts into practice well-established recommendations from learning sciences. TBL's decades-long success in medical and health sciences, engineering and law further suggests that economics educators carefully examine TBL's potential in our discipline.

Table 1 below summarizes the key elements of TBL, along with the learning sciences principles most closely aligned with each element. The formal, whole-course structure of TBL, with a systematic, repeated cycle of learning that includes a Readiness Assurance Process (RAP) and

Application Exercises (AEs) within each module, continually reinforces students' learning throughout a semester-long course in an intentional way, supported by research from the learning sciences.

Table 1. Key Elements of TBL and Associated Learning Sciences Principles

TBL Element	Learning Sciences Principles Involved
1. Readiness Assurance Process	
• iRAT quiz	Retrieval practice, spaced practice
• tRAT quiz	Retrieval practice, spaced practice, elaboration
• Team Appeals	Elaboration
• Mini-lecture	A time for telling
2. Application Exercises	Retrieval practice, spaced practice, concrete examples, elaboration
• AE Debriefing	A time for telling
3. Instructor-selected fixed teams and formal peer evaluations	Promoting effective group work; reinforces and enhances the effect on student learning of each TBL element

Several research questions arise. Should TBL be adopted in pieces, or is it necessary to implement all of its features, as TBL originators recommend? In our experience, instructors new to the pedagogy often begin with the readiness assurance process, iRATs and tRATs using IF/AT forms, because it requires little new preparation and is popular with students. More difficult is adoption of application exercises because they require relatively extensive preparation of new in-class materials. The main purpose of our National Science Foundation project is to reduce this cost by creating an extensive, freely-available library of ready-to-use AEs (see https://serc.carleton.edu/econ/tbl-econ/activities.html).

Assessing TBL's impact on student learning is an additional challenge. In 2020 our NSF project will complete a multi-campus study of student learning in Principles of Microeconomics courses when Application Exercises are employed in place of problems traditionally used in the classroom. A more complete assessment of TBL would include the synergistic effects of the entire TBL pedagogy from the Readiness Assurance Process to Application Exercises to peer evaluation. That type of evaluation raises difficult measurement issues such as instructor effects when there is such a complete change in a course's pedagogy and design. Carl Wieman's physics education research group has attempted this type of evaluation with provocatively positive evidence for extensive change in the structure of a physics course (Deslauriers, 2011). Similar projects might be undertaken in economics to better understand the efficacy of implementing evidence-based instructional strategies.

Finally, evaluation raises potentially tricky issues about what constitutes students' learning. Even in carefully-controlled laboratory experiments, learning scientists have found that measuring student learning beyond recall requires attention to the *transfer* of understanding. For example, Schwartz's (1998) investigation of *A Time for Telling* noted above, found that traditional instruction was as effective as the alternative pedagogy if the evaluation tool measured simple comprehension. What the treatment pedagogy added was the ability for students to apply understanding in new contexts, an outcome not usually measured. In some disciplines, researchers have developed "concept inventories" that probe student understanding of core concepts in new contexts, in particular the ideas that students take with them outside the classroom (Maier & Simkins, 2011). A full appraisal of TBL (and other evidence-based teaching practices) in economics likely will require such a concept inventory in economics; at present no such inventories exist in the discipline.[7]

In summary, TBL offers economics education offers great potential as well as challenges. These apply both to implementing TBL in the curriculum as well as its implications for its study by economics educators.

APPENDIX: TBL IN A PRINCIPLES OF MICROECONOMICS CLASS – AN EXAMPLE

Phil Ruder has taught his 54-student *Principles of Microeconomics* courses at Pacific University in Forest Grove, Oregon, using TBL pedagogy for six years. A description of the steps involved in teaching that class provides a detailed example to accompany the general description of TBL teaching practices in the paper.

Step 1. Divide the course content into modules. Before the course begins, the instructor divides the course into six modules that are presented, along with corresponding content from the *Principles of Microeconomics* text (Frank, et al., 2019) used, in Table A.1. Each module follows the readiness assurance process (RAP) and application exercise (AE) sequence described below.

Table A.1. Modules in Ruder's *Principles of Microeconomics* Course

Module	Title	Frank, et al., Chaps.	Chapter Content
1	Thinking like an economist	1-2	Economic principles, comparative advantage
2	Supply and demand	3-4	Supply, demand, elasticity
3	Perfect competition	6-7	Perfectly competitive supply, competitive markets
4	Market failure – imperfect competition	8-9	Imperfect competition, game theory
5	Other market failures	11-12	Externalities, information
6	Public policy	13-14	Labor markets, income inequality, public goods, taxes

[7] While the Test of Understanding College Economics (TUCE) is a nationally norm-referenced, standardized test that has been used extensively for measuring learning gains in economics courses (especially at the principles level), it differs from concept inventories such as the Force Concept Inventory (FCI) developed in physics (Hestenes, Wells, & Swackhamer, 1992), which focuses on "commonsense misconceptions." The FCI is arguably the oldest and most well-known concept inventory and has led to the development of a wide variety of additional concept inventories, primarily in STEM disciplines.

Step 2. Create teams. On the first day of class, the instructor has students organize themselves into a single line stretched around the perimeter of the classroom. Students first assemble themselves in order of their (first) major and then alphabetically by first name within each major. The students then count off by the number of teams in the class – e. g., there are nine six-student teams in Ruder's 54-student class. Students then take up seats in the area designated for their team by the numbered folder placed in each area before class. Students sit in that area for the rest of the semester.

The linear team selection method described here has the advantages of (1) getting students to "break the ice" among themselves on the first day of the course,[8] (2) distributing students with different quantitative skills, which are highly correlated with major, evenly across the teams, (3) and transparency to students.

One common alternative method of creating teams is to administer a student survey on the first day of class and, before the second class period, carefully engineer teams to achieve as much diversity as possible – gender, race, quantitative skill level, sports team membership, etc. This method of creating teams has the advantage of attaining great team diversity and avoiding pitfalls such as placing a single woman or minority student alone on a team with five members of the majority group. However, when teams emerge from the professor's "black box," any team disfunction is more likely to be blamed on the professor and it is more difficult to get students to resolve issues on their own. Moreover, in Ruder's experience, carefully engineered teams seem to function no better than the randomly created teams in the linear method.

Step 3. Carry out the Readiness Assurance Process (RAP). In Ruder's course, students read and take careful notes on the textbook chapters assigned for the module *before* the first day of the module. The first 95-minute class begins with students taking a 20-question, open-note, closed-book, multiple choice, individual quiz (an iRAT, see Figure 1) on a form that is graded immediately using the Zipgrade app (www.zipgrade.com) on the instructor's phone. Students take an identical quiz as a team (a tRAT, see Figure 1) using Immediate Feedback Assessment Technique (IF-AT) forms (available from Epstein Educational Enterprises www.epsteineducation.com) that offer teams reduced points when they require more than one attempt to answer a question and reveal the correct answer during the course of the quiz.

Ruder assembles the iRAT/tRAT quizzes from the publisher test bank, after filtering out questions rated as "easy" by the publisher. In Ruder's experience, the easy questions fail to promote sufficient retrieval effort from individual students and give teams little to discuss beyond polling each team member to determine their individual response. The iRAT/tRAT quiz questions reach the application level of Bloom's taxonomy. Table A.2 presents examples of iRAT/tRAT quiz questions from the externality unit of the material (Module 5).

After teams have completed the quiz and handed in their IF-AT form, teams can challenge any quiz question by consulting the text and creating a written argument based on evidence from the text that a particular question had two correct answers, no correct answer, or drew on knowledge that students could not reasonably be expected to know. The instructor reviews appeals before the next class and, in the case of a successful appeal, awards the team double the points at issue. There is no penalty for an unsuccessful challenge.

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[8] Simkins uses the "Marshmallow Challenge" on the first day of class to develop team functionality and set the stage for team-based activities throughout the semester; see http://www.leadershipchallenge.com/resource/challenging-the-process-with-the-marshmallow-challenge.aspx.

After the tRAT quiz and challenge process, the instructor presents a mini-lecture to explain iRAT/tRAT quiz questions that any team missed and to review elements of the material that require explanation beyond the reading before students can proceed to apply the material in a sequence of increasingly difficult team application exercises.

Table A.2. iRAT/tRAT Quiz Question Examples from Externality Unit

Example 1. Consider two restaurants located next door to each other: Quick Burger and The Sunshine Café. If Quick Burger opens a drive-through window, the increased traffic and noise will bother customers seated outside at The Sunshine Café. The table below shows the monthly payoffs to Quick Burger and The Sunshine Café when Quick Burger does and does not operate a drive-through window.

	Quick Burger Operates a Drive-Through Window	**Quick Burger Does Not Operate a Drive-Through Window**
Quick Burger	$24,000	$15,000
The Sunshine Café	$11,000	$23,000

If Quick Burger has the legal right to operate a drive-through window, then the Sunshine Café would have to pay Quick Burger at least ____ per month NOT to operate a drive-through window.

a. $9,000
b. $11,000
c. $15,000
d. $24,000

Example 2. Compared to a fixed percentage reduction (command and control) regulation, a tax on pollution encourages:
a. firms that can more cheaply reduce pollution to make larger reductions.
b. firms to reduce pollution by the same percent.
c. firms to use the same technology to reduce pollution.
d. big firms to make larger reductions because they can more easily afford it.

The mini-lecture that concludes the RAP takes up the final 20 minutes of the first class period of the module. After class, Ruder posts (to the class LMS) five or six 8-minute screencasts to explain related RAP questions, along with additional screencasts that review important concepts and provide additional examples, and provides students with links to selected outside sources that present information on the topics under study.

Together, the individual and team quizzes amount to 15-20% of the course grade. Typically, individual students average 60% correct on iRATs and teams average 90% correct on tRATs. Average team quiz scores always exceed the averages of the best-performing individual team members, usually by a wide margin.

Step 4. Implement a Series of Application Exercises. Most of class time in a TBL course consists of work in teams on application exercises (AEs). Student preparation before AE classes consists of work on traditional problems, data analysis, and/or readings, videos, and podcasts related to cases in the upcoming AEs. Having students answer Just-in-Time-Teaching (JiTT) questions via the course LMS prior to class generally increases their readiness to participate in the AEs.

Each AE follows the ***"set-body-close"*** format in which the instructor begins the activity by reviewing any new analytical frameworks that might be important for student work in the AE and/or describing the analysis that will be required to be in reporters' notes to support team choices (the instructor ***sets the stage*** for carrying out the AE). The ***body*** *of the AE* consists of student work in teams to determine a consensus choice in a 4S TBL AE, followed by an instructor-facilitated conversation among team reporters. Each AE ***closes*** with the instructor reviewing key points that emerged in the conversation among reporters and providing an expert's take on the issue at the center of the AE.

Students work on AEs of increasing complexity in the classes following the RAP. The instructor typically begins with several short AEs that emphasize the basics of the analytical frameworks of the unit and then proceeds to challenge students with AEs that pose complex problems and offer multiple defensible choices for students to consider. Table A.3 presents a relatively complex AE from the unit on externalities (Module 5), along with several questions prepared in advance to facilitate the conversation among reporters.

In this example, the AE comes after students have prepared for class at home by (1) viewing a television news story on the issue, and (2) responding to several JiTT questions in the LMS. The purpose of these questions is two-fold: first, to connect the material in the textbook reading to the news story; second, to hold students accountable for preparing for class. Note that multiple possible answers can be reasonably defended. Ruder has reporters present their answers in two phases. First, randomly selected reporters present the economic framework analyzing the externality issue; second, the reporters defend their choice regarding the best policy response.

Ideally, student work in teams focuses on developing the understanding of each member of the team. In that way, as the team works to prepare its answer, each student is encouraged to express her/his understanding and receive formative feedback from teammates. To encourage a productive focus for each team, in Ruder's classes student reporters are selected randomly by means of a customized "spinning wheel app" (see Google Play or the App Store for options) only after the teams have concluded their work to make the required choice and prepare the supporting analysis. Teams lose no AE points (typically ten to fifteen percent of the grade) for making an inferior choice; however, if any randomly-selected reporter cannot explain the team's reasons for making the choice or lacks the required support in their notes, the entire team loses one of the semester's AE points – usually one percent of the course grade. During the first AE classes of the semester, Ruder issues warnings instead of deducting points, but from the third week on, teams lose points for an insufficient report by any member. (Such shortcomings are very rare after week two.)

Table A.3. Example of a TBL AE and Facilitation Questions in the Externalities Unit

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Water Pollution and Drinking Water in Des Moines, IA

Consider the issue of nitrate pollution by farms in Iowa fouling the Raccoon and Des Moines Rivers, the sources of drinking water for the City of Des Moines, IA.

What policy measure should be enacted to remedy the problem?

A. Require substantial reductions in nitrate use of all farms.
B. Tax each ton of nitrate applied to farms.
C. Assign property rights over the river water clearly to the City of Des Moines.
D. Assign property rights over the river water clearly to farmers.

(*Note: student reporters should be prepared with the appropriate analysis of this issue using the basic externality framework for this case in their notes.*)

Instructor Facilitation Questions

1. Explain why your team chose your answer. (Ask this of one or two students making each choice.)
2. Why didn't your team choose answer ___?
3. If the property rights are clearly defined, are negotiation costs low enough that we could expect private parties to come to an efficient solution? Why or why not?

Step 5. Conduct teammate assessments. Teammates rate each other on their performance as team member, rating each other on 12 criteria such as, "asks useful or probing questions," "is well-prepared for team activities," and "gives useful feedback to others."[9] Students also provide written comments describing the single most-valuable contribution of each teammate and the most important way each teammate could improve their contribution to the team. Several formative assessments are administered throughout the semester in which students receive teammate ratings and the comments with the goal of improving performance during the course of the semester.

The final teammate assessment ratings are used to adjust the tRAT and AE points received in the course. Any student receiving less than a 70% rating from teammates fails the course. In practice, the minimum teammate rating is 80%, most ratings range between 95 and 100%, and less than one in twenty students gets rated below 90%.

[9] See, for example, the peer feedback and evaluation discussion (with examples of forms) at https://cft.vanderbilt.edu/guides-sub-pages/team-based-learning/.

Step 6. What about summative assessments in a TBL course? In addition to the low-stakes, formative assessments – iRAT and tRAT quizzes, online short essays with JiTT questions in preparation for AE classes, and the team-based work on AEs – Ruder's courses include the following, mostly individual summative assessments: four problem sets, four exams, and a comprehensive final.

- ***Problem sets.*** Problem sets consist largely of traditional practice problems to sharpen those skills, which receive less emphasis in the conceptually rich TBL AEs.
- ***Exams.*** Exams consist of a mixture of questions from the problem sets and the TBL AEs. Ruder provides students with a study guide that helps them anticipate test questions that will arise from the TBL AEs. Individuals take the exams first, then the team takes each exam together. If the team score is better than the individual's test score, the student exam grade is an 80-20 weighted average of the individual and team exam, respectively. Alternatively, instructors can administer a summative assessment at the conclusion of each module.
- ***Comprehensive final.*** The final spans the entire semester's material, though Ruder provides students with a study guide that specifies a large set of problems, short essay questions, and long-essay questions that might be on the final. There is no team phase of the final exam. The only teammate assessment that counts toward the final grade is administered with the final exam.

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